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(54) **TRANSPARENT ENDOSCOPE HEAD DEFINING A FOCAL LENGTH**

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(58) **Field of Classification Search**

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See application file for complete search history.

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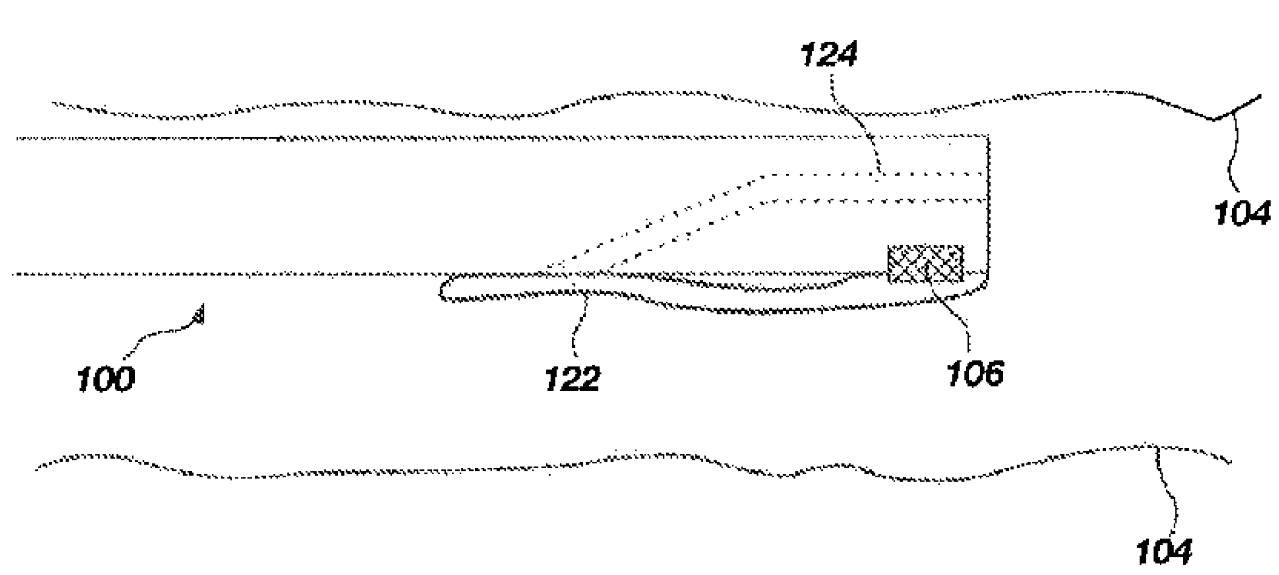
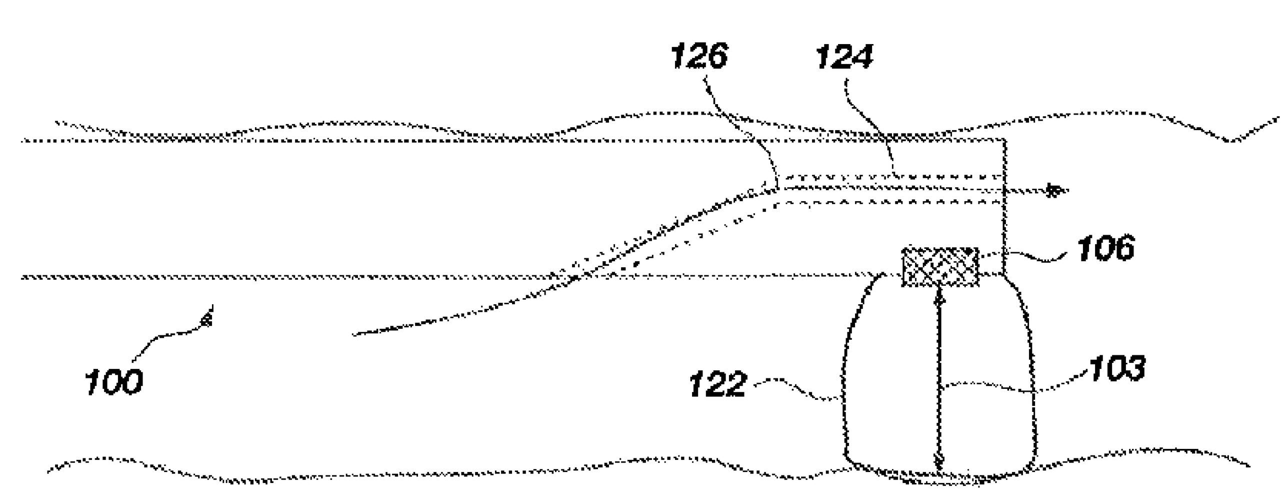
(57) **ABSTRACT**

A catheter configured for imaging objects substantially in focus is described herein. An imaging device is disposed on the distal end of the catheter. The imaging device has an effective focal plane that is located in front of the imaging device. The catheter also includes a transparent focal instrument that has an outer periphery that is positioned at the effective focal plane of the imaging device, to enable objects in contact with the outer periphery of the transparent focal instrument to be imaged substantially in focus.

14 Claims, 8 Drawing Sheets





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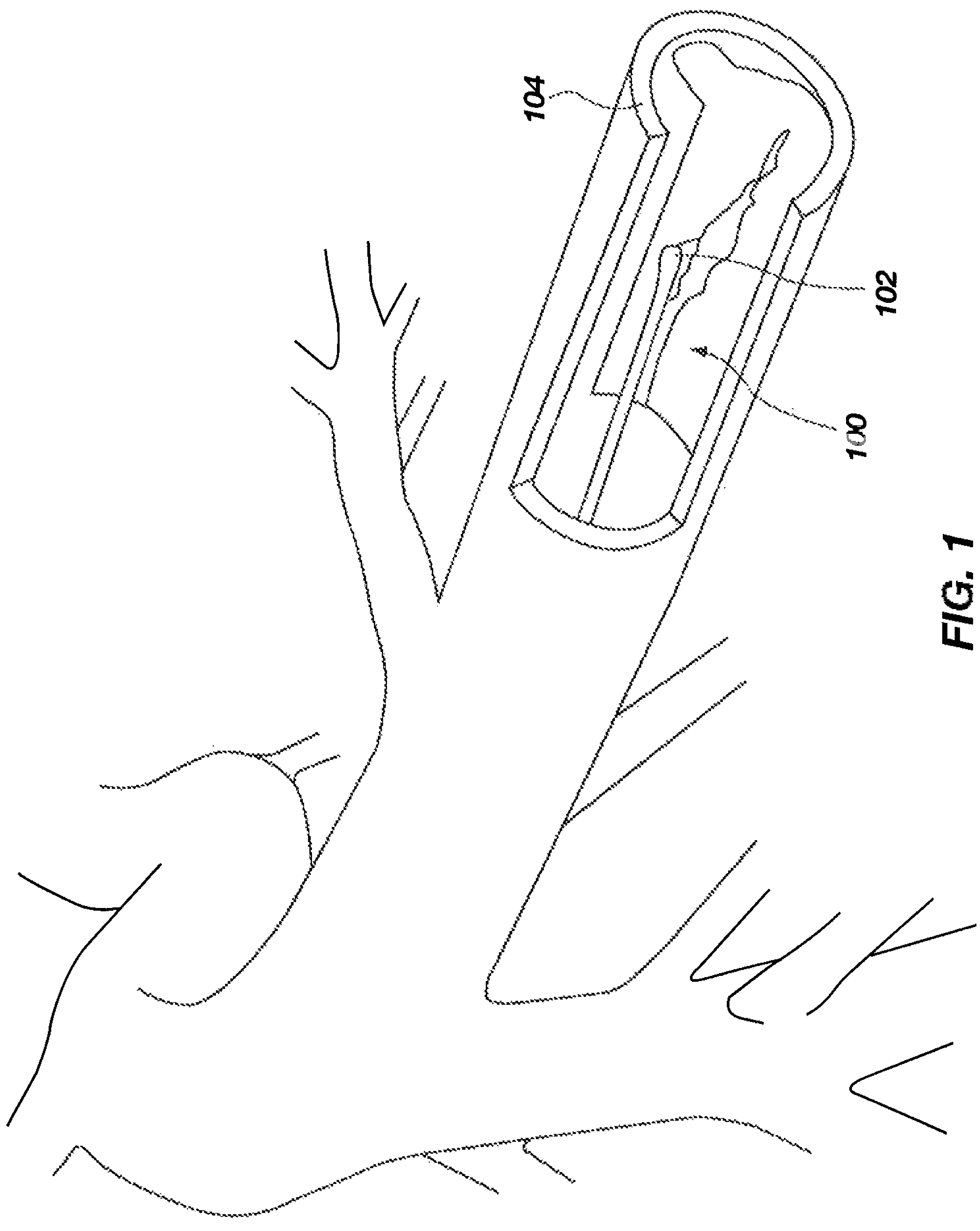

FIG. 1

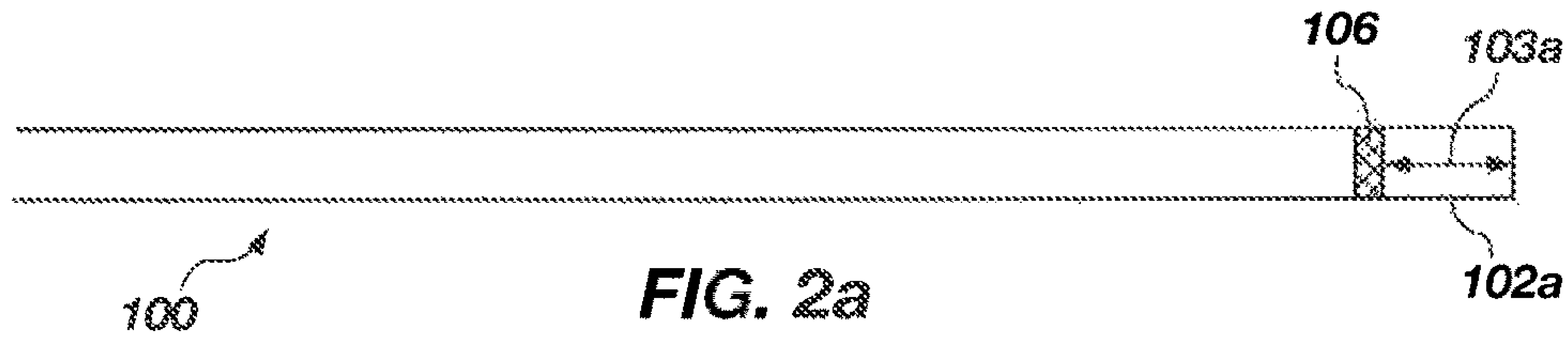

FIG. 2a

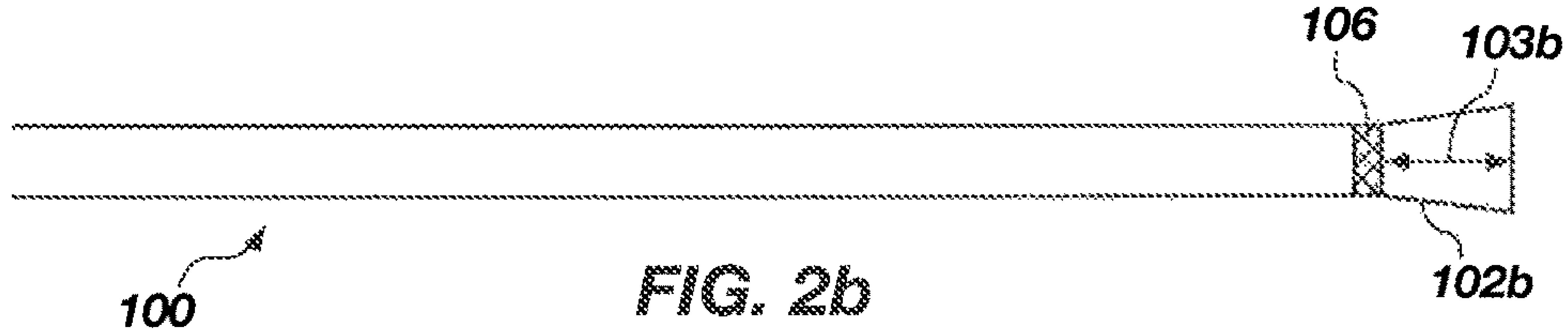

FIG. 2b

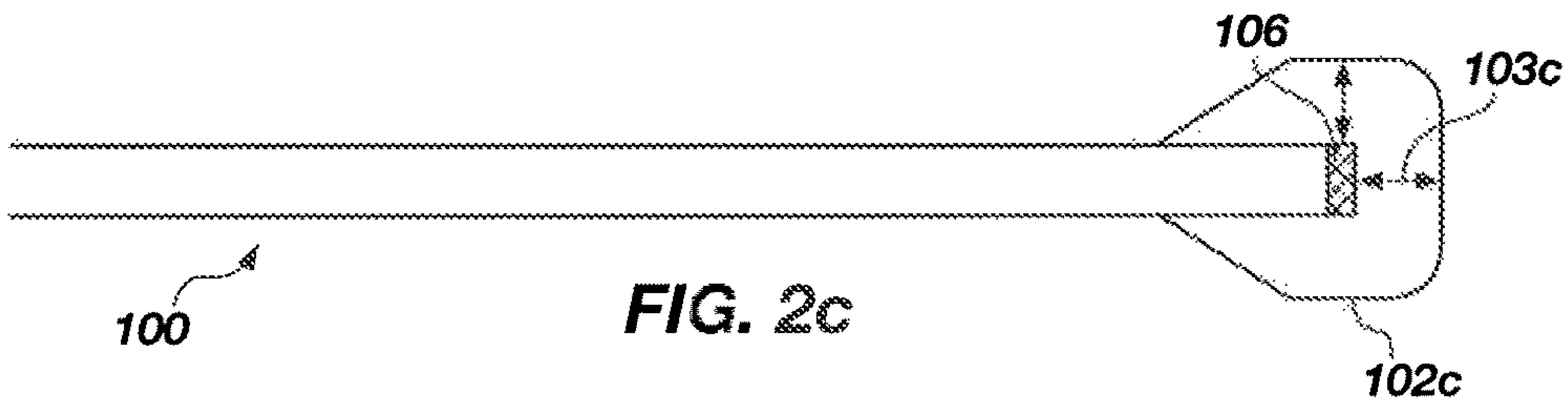

FIG. 2c

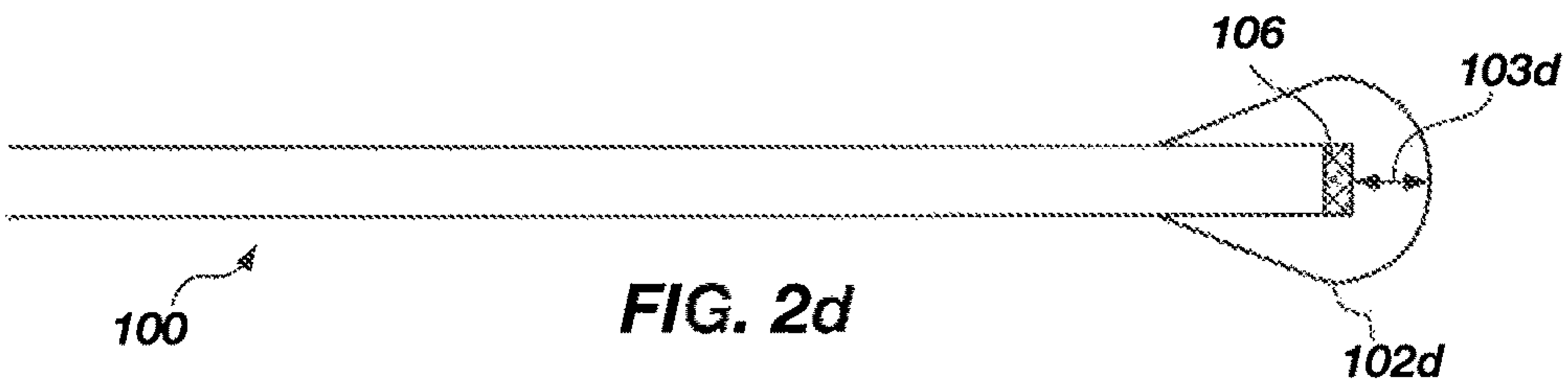

FIG. 2d

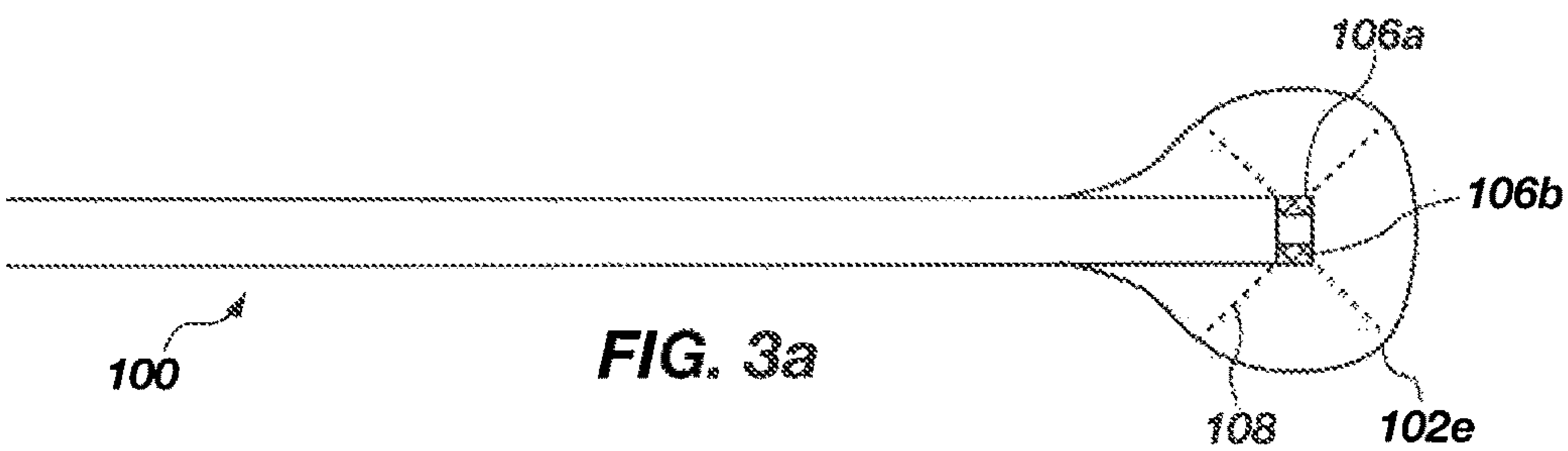

FIG. 3a

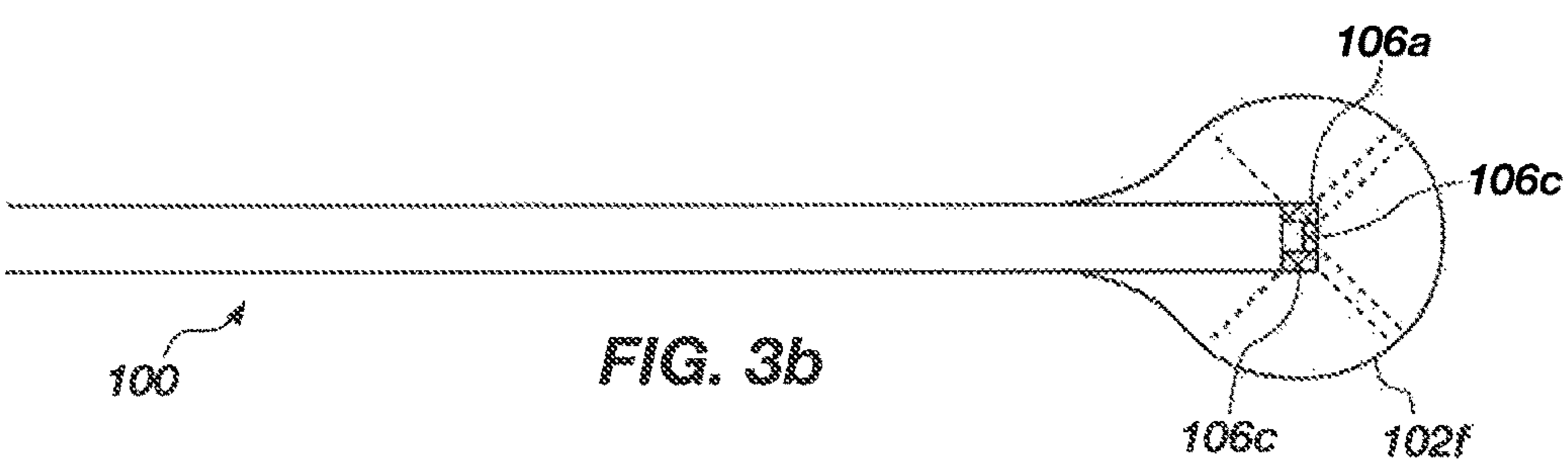

FIG. 3b

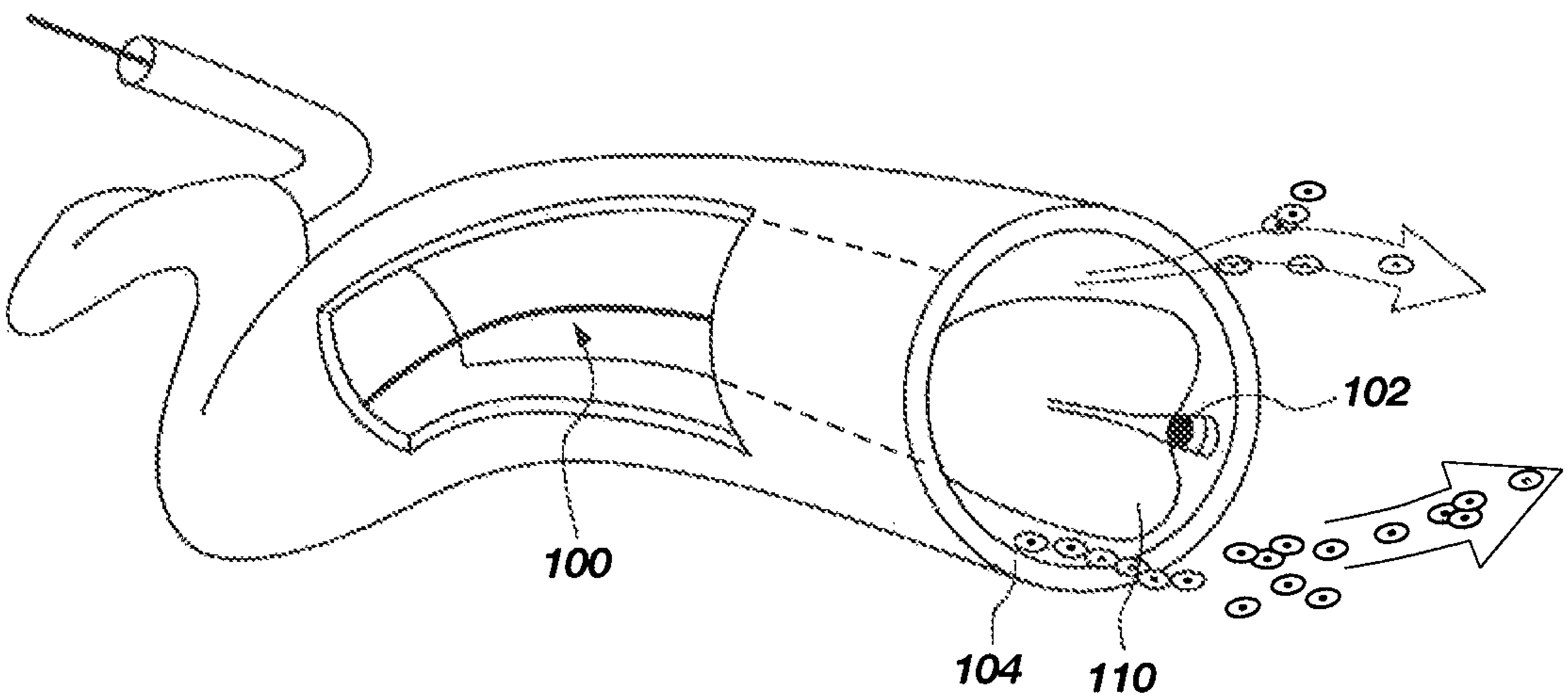

FIG. 4

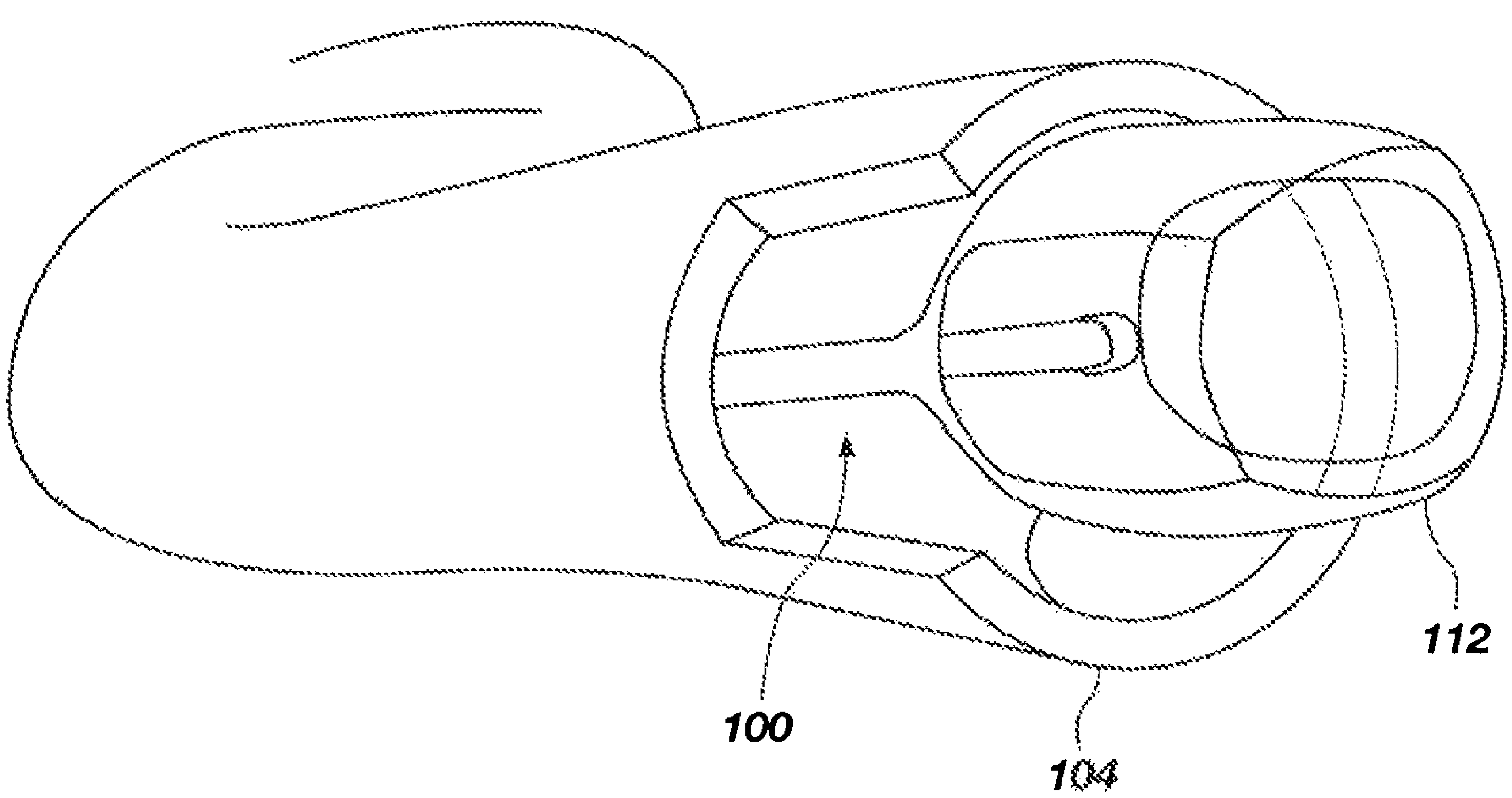

FIG. 5

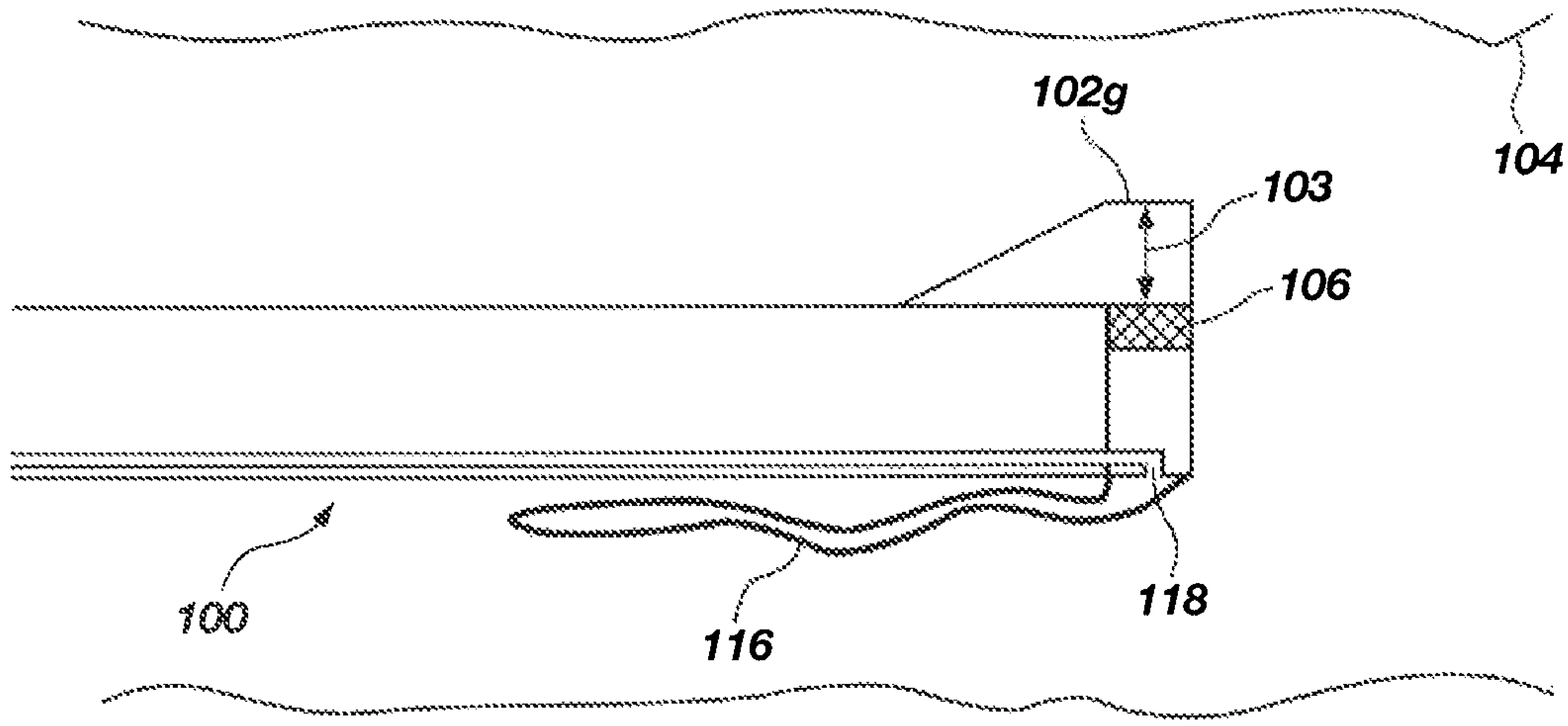

FIG. 6a

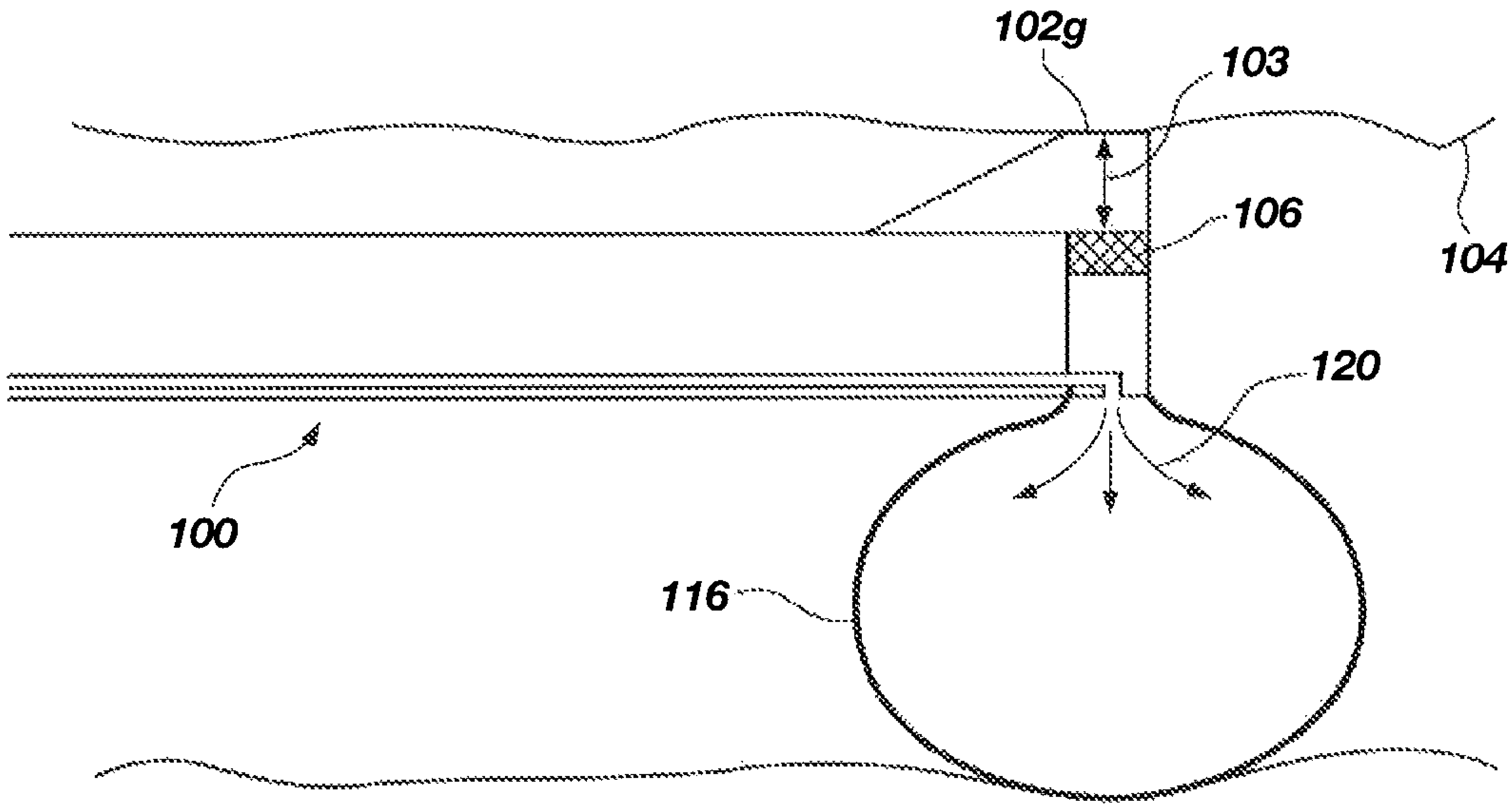

FIG. 6b

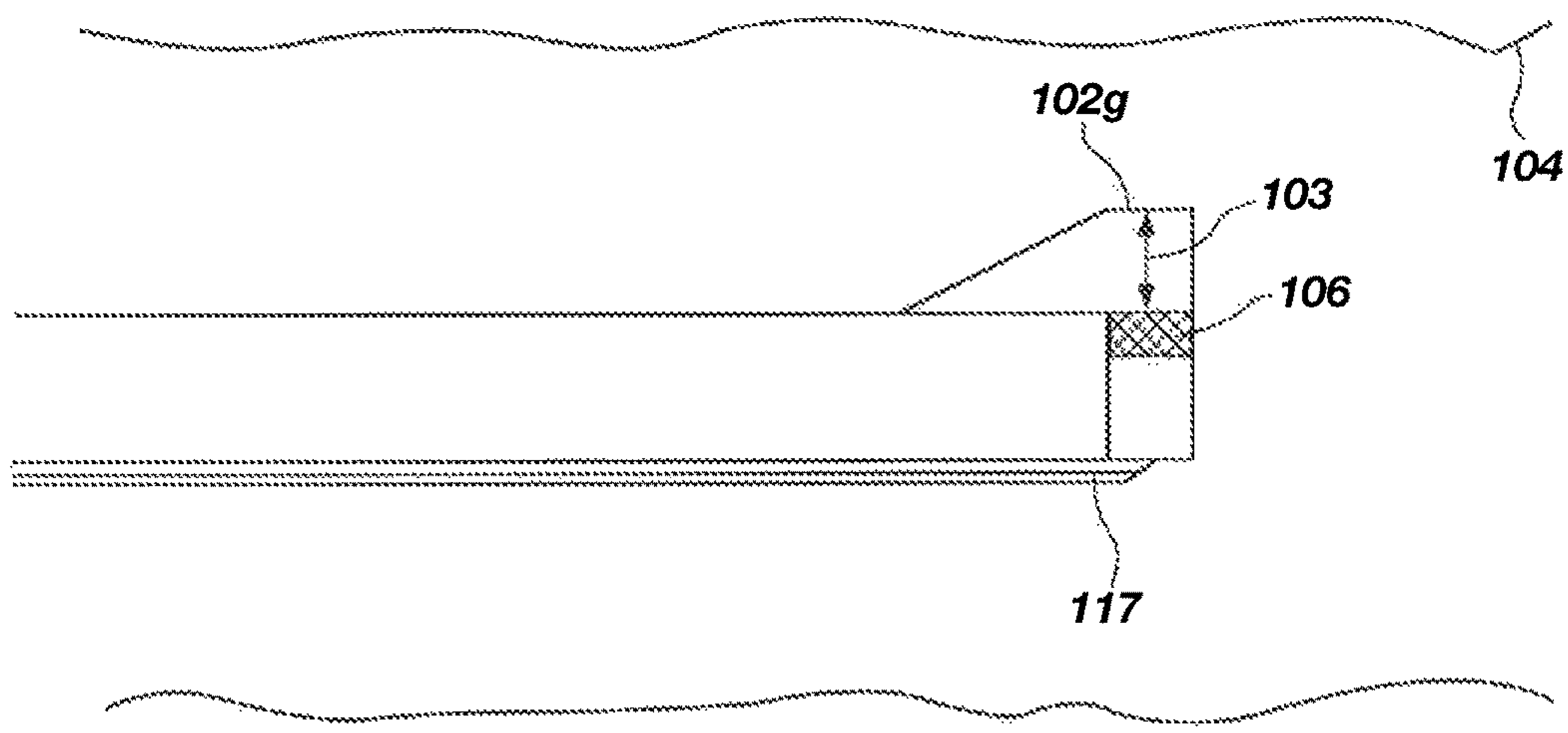

FIG. 6c

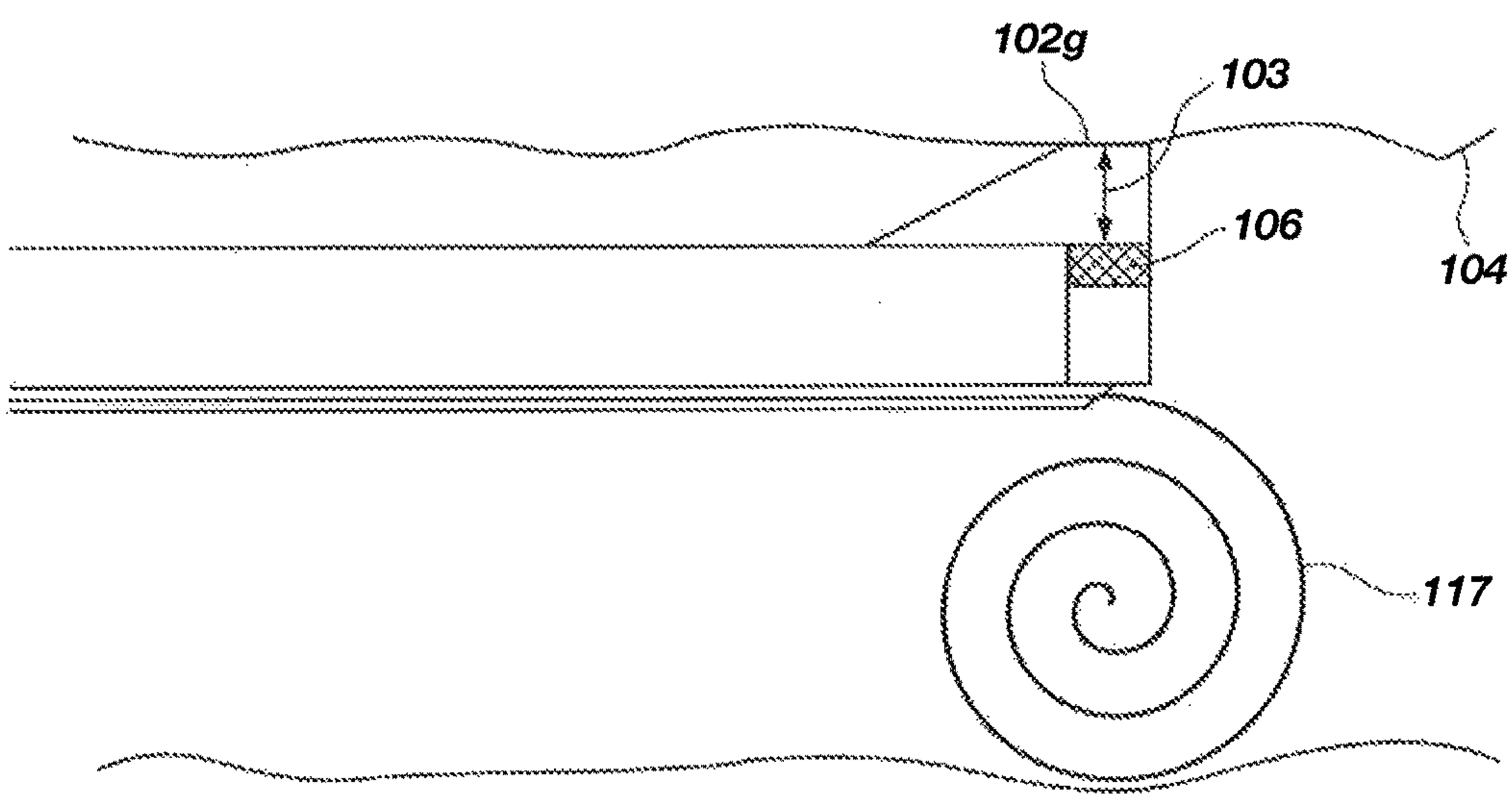

FIG. 6d

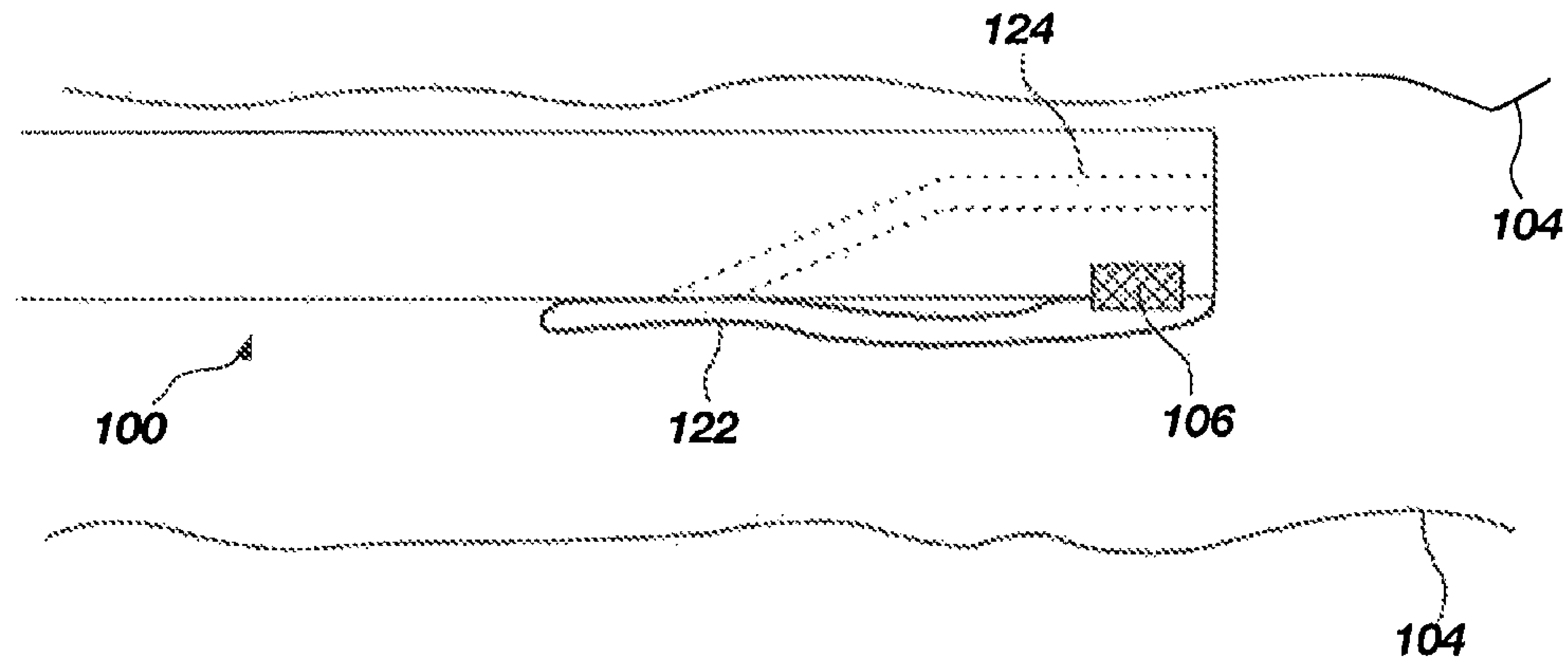

FIG. 7a

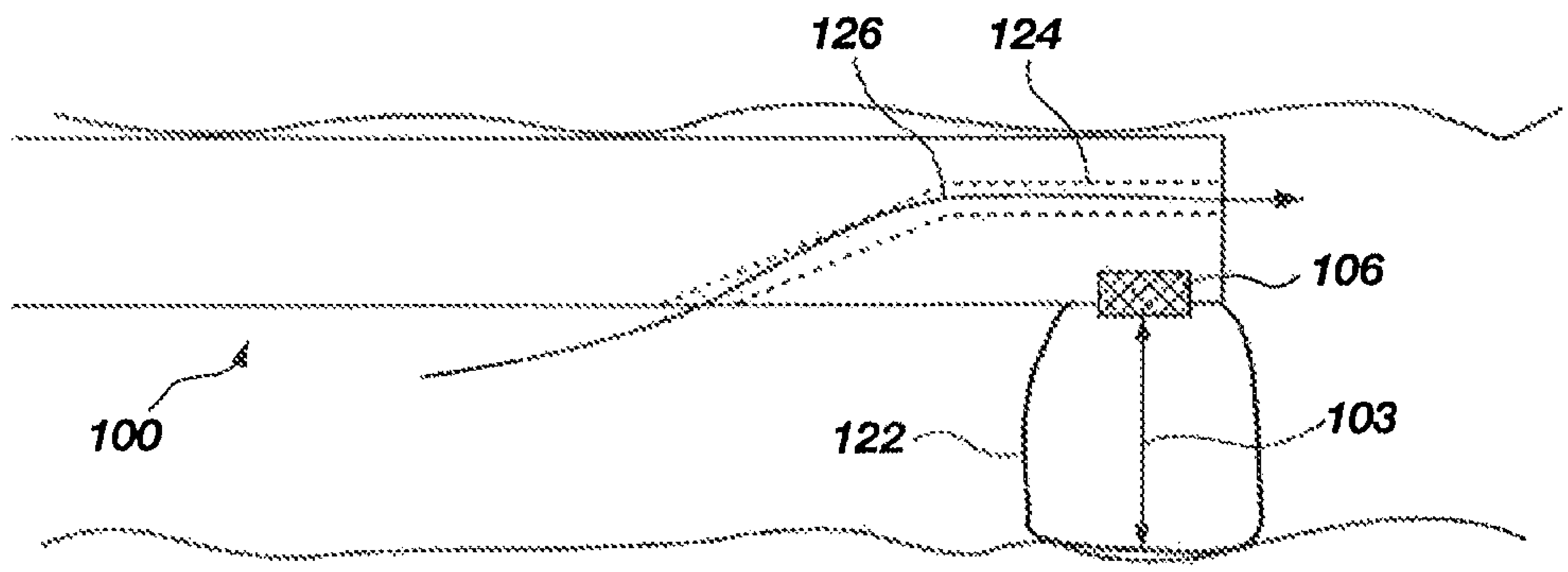

FIG. 7b

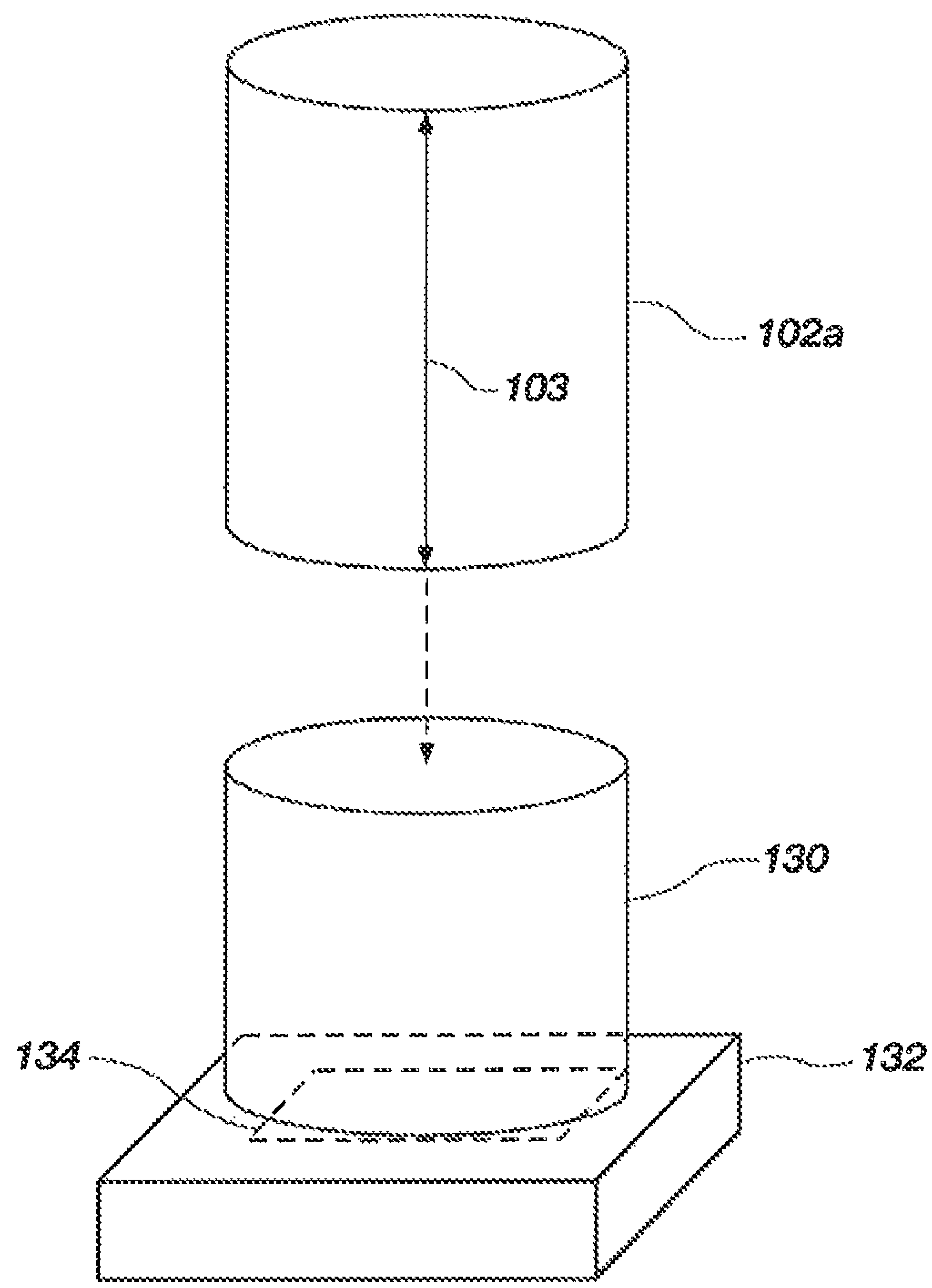

FIG. 8

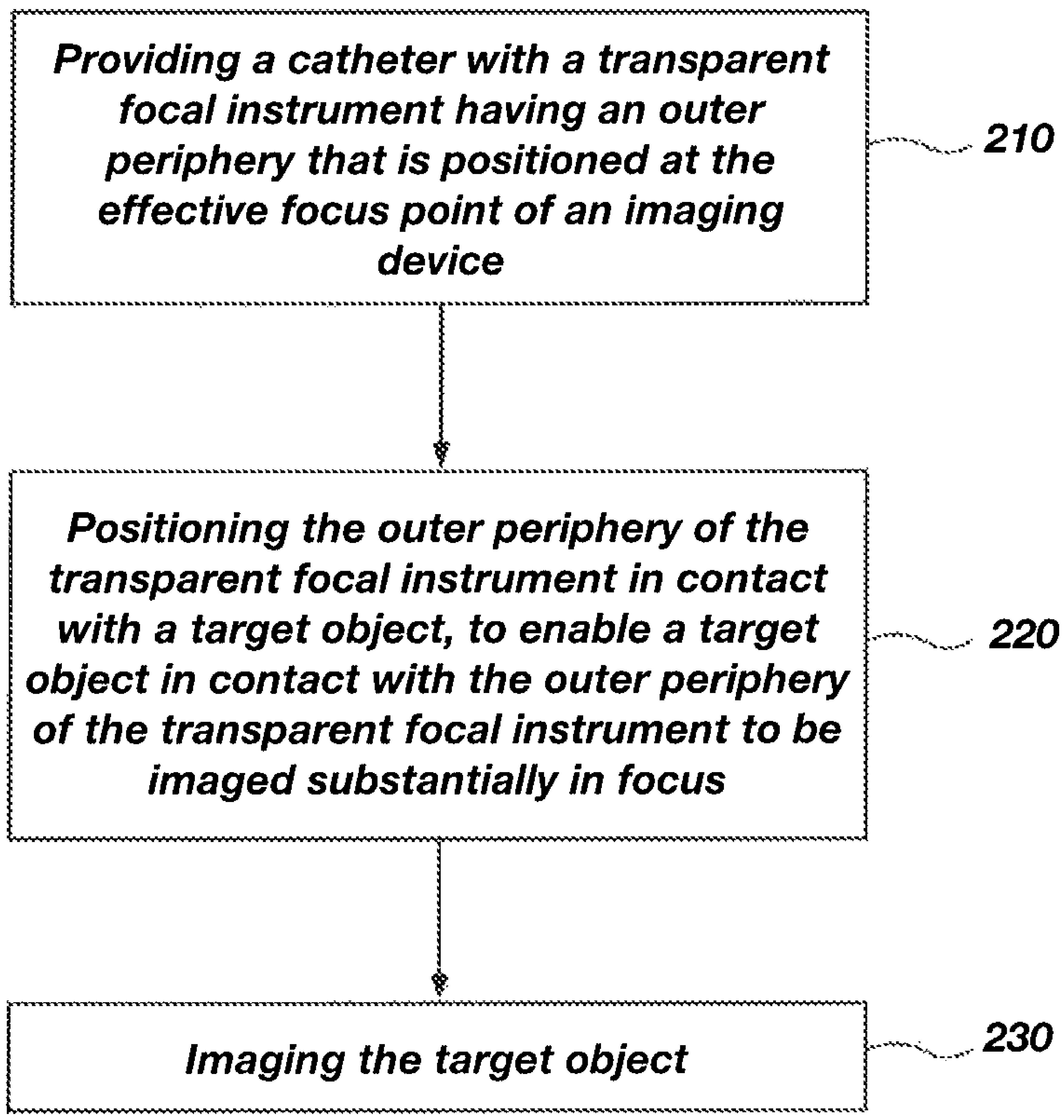
Providing a catheter with a transparent focal instrument having an outer periphery that is positioned at the effective focus point of an imaging device
210
Positioning the outer periphery of the transparent focal instrument in contact with a target object, to enable a target object in contact with the outer periphery of the transparent focal instrument to be imaged substantially in focus
220
Imaging the target object
230

FIG. 9

TRANSPARENT ENDOSCOPE HEAD DEFINING A FOCAL LENGTH

PRIORITY

This application is a continuation of U.S. Ser. No. 12/487,495 filed on Jun. 18, 2009 entitled, "Transparent Endoscope Head Defining a Focal Length" and given patent number U.S. Pat. No. 8,690,762 claims priority to U.S. Provisional Ser. No. 61/132,566 filed on Jun. 18, 2008 entitled "Transparent Endoscope Head Defining a Focal Length" which are both incorporated herein by reference in their entirety.

FIELD OF THE INVENTION

The present invention relates to medical devices, and more particularly to miniaturized in-situ imaging devices and methods of operation of said devices.

BACKGROUND

The present invention relates generally to the field of endoscopy. More particularly, the present invention relates to improved endoscopic and catheter imaging.

Small imaging devices have become particularly useful in medical diagnostic and treatment applications. Portions of human anatomy previously viewable only by a surgical procedure can be viewed now by a minimally invasive catheterization, provided an imaging device can be made that is small enough to view the target anatomy.

Other uses for very small imaging devices are recognized. For example, such devices can be used and are desirable for surveillance applications, for monitoring of conditions and functions within devices, and for size and weight-critical imaging needs as are present in aerospace applications, to name a few.

While the present invention has applications in these aforementioned fields and others, the medical imaging application can be used to favorably illustrate unique advantages of the invention. The desirability of providing imaging at sites within the anatomy of living creatures, especially humans, distal of a small orifice or luminal space has long been recognized. A wide variety of types and sub-types of endoscopes have been developed for this purpose,

One advance in imaging technology which has been significant is the increased reduction of individual component sizes. Presently, charged coupled devices (CCD) such as miniature cameras can be manufactured so as to fit on the end of a catheter approximately the size of a couple of strands of wire. Lenses, optical fiber, and miniature surgical equipment can also be produced in miniature dimensions. However, these devices although functional and increasingly effective, can be difficult to position in order to appropriately image small areas of a target tissue.

For example, small cell carcinoma tends to start in the larger breathing tubes of the lungs. In its early stages it may only affect a small number of cells, covering a distance of only 20-40 microns across. Because it could be advantageous to image and diagnose this problem in this early stage before it rapidly grows and becomes quite large it is important to be able to access, locate and image these small areas. High resolution imaging can effectively view these cells if such locations can be found and if the imaging device can be appropriately positioned, focused, and imaged. This process is increasingly complicated in cases, such as small cell carcinoma, wherein the cell clusters are located in large passageways. While a larger endoscope could be used for this procedure, a small catheter will substantially minimize patient trauma and duress. Presently, a user will be required to repeatedly move a small catheter or endoscope forward-and-backward, side-to-side in a trial and error fashion in attempts to acquire the target area within focus of the miniature camera. Typically, this process results in images that are not in complete focus and that can be difficult to diagnose.

SUMMARY

It has been recognized that it would be advantageous to develop a catheter that can be easily and effectively positioned so that a target object can be imaged substantially in focus.

Briefly, and in general terms, the invention is directed to a catheter configured for imaging objects substantially in focus. An imaging device is disposed on the distal end of the catheter. The imaging device has an effective focal plane that is located in front of the imaging device. The catheter also includes a transparent focal instrument that has an outer periphery that is positioned at the effective focal plane of the imaging device, to enable objects in contact with the outer periphery of the transparent focal instrument to be imaged substantially in focus.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more fully apparent from the following description and appended claims, taken in conjunction with the accompanying drawings. Understanding that these drawings merely depict exemplary embodiments of the present invention they are, therefore, not to be considered limiting of its scope. It will be readily appreciated that the components of the present invention, as generally described and illustrated in the figures herein, could be arranged and designed in a wide variety of different configurations. Nonetheless, the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

FIG. **1** is a schematic illustration of an exemplary catheter in accordance with principles of the invention;

FIG. **2***a* is a side view of one embodiment of the catheter of FIG. **1**;

FIGS. **2***b*-**2***d* are side views of other embodiments of the catheter of FIG. **1**;

FIGS. **3***a* -**3***b* are side views of yet other embodiments of the catheter of FIG. **1**;

FIG. **4** is a schematic illustration of a catheter having an inflatable balloon to position the imaging device in accordance with one embodiment of the invention;

FIG. **5** is a schematic illustration of an exemplary catheter having an inflatable balloon as a transparent focal instrument, in accordance with one embodiment of the invention;

FIGS. **6***a* and **6***b* are side views of one embodiment of the catheter of FIG. **4**;

FIGS. **6***c* and **6***d* are side views of an additional embodiment of the catheter of FIG. **4**;

FIGS. **7***a*-**7***b* are side views of one embodiment of the catheter of FIG. **5**;

FIG. **8** is a perspective view of one embodiment of the imaging device of FIG. **2***a*; and

FIG. **9** is a flowchart of a method for imaging with a catheter according to one embodiment of the present invention.

Reference will now be made to the exemplary embodiments illustrated, and specific language will be used herein to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENT(S)

The following detailed description of exemplary embodiments of the invention makes reference to the accompanying drawings, which form a part hereof and in which are shown, by way of illustration, exemplary embodiments in which the invention may be practiced. While these exemplary embodiments are described in sufficient detail to enable those skilled in the art to practice the invention, it should be understood that other embodiments may be realized and that various changes to the invention may be made without departing from the spirit and scope of the present invention. Thus, the following more detailed description of the embodiments of the present invention, as represented in FIGS. **1** through **9**, is not intended to limit the scope of the invention, as claimed, but is presented for purposes of illustration only and to sufficiently enable one skilled in the art to practice the invention. Accordingly, the scope of the present invention is to be defined solely by the appended claims.

The following detailed description and exemplary embodiments of the invention will be best understood by reference to the accompanying drawings, wherein the elements and features of the invention are designated by numerals throughout. In describing and claiming the present invention, the following terminology will be used.

The singular forms "a," "an," and "the" include plural referents unless the context clearly dictates otherwise. Thus, for example, reference to "a camera device" includes reference to one or more of such camera devices, and reference to "an inflatable balloon" includes reference to one or more of such inflatable balloons.

As used herein, "catheter" refers to any one of a variety of catheter or endoscopic systems designed to imaging within the anatomy of living creatures or other appropriate system wherein imaging, surveillance, or other need is present. In one embodiment the catheter can comprise a miniature catheter having a SSID chip and a GRIN lens for imaging small locations with high resolution. Other imaging systems can be incorporated as will be apparent to one of ordinary skill in the art.

As used herein, "effective focal plane" or "main focal plane" refers to forward location in front of a camera/imaging device at which an object(s) is/are substantially in sharp focus or "in focus". It is not intended that this location be a single point in space, rather it is intended that this focal point refer to the two or three-dimensional area in which an imaging device can image an object substantially in focus. An object imaged at this distance from the camera, given the proper lighting conditions, can have higher resolution and increased clarity than an object imaged at a closer or further distance. This effective focal plane will vary with different camera and imaging devices, as will be appreciated by one of ordinary skill in the art.

As used herein, "imaging device" refers to any one of the variety of catheter and endoscopic imaging devices, camera systems, fiber bundles, and other such devices known in the art. For example, the imaging device can include a SSID having an imaging array and a lens, as will be described in greater detail below.

As used herein, "solid state imaging device" or SSID in the exemplary embodiments generally comprises an imaging array or pixel array for gathering image data, and can further comprise conductive pads electrically coupled to the imaging array, which facilitates electrical communication therebetween. In one embodiment, the SSID can comprise a silicon or other semiconductor substrate or amorphous silicon thin film transistors (TFT) having features typically manufactured therein. In another embodiment, the SSID can comprise a non-semiconductor substrate coated with a semiconductor material, or other equivalent structure. Features can include the imaging array, the conductive pads, metal traces, circuitry, etc. Other integrated circuit components can also be present for desired applications. However, it is not required that all of these components be present, as long as there is a means of gathering visual or photon data, and a means of sending that data to provide a visual image or image reconstruction.

"GRIN lens" or "graduated refractive index lens" refers to a specialized lens that has a refractive index that is varied radially from a center optical axis to the outer diameter of the lens. In one embodiment, such a lens can be configured in a cylindrical shape, with the optical axis extending from a first flat end to a second flat end. Thus, because of the differing refractive index in a radial direction from the optical axis, a lens of this shape can simulate the affects of a more traditionally shaped lens. In one embodiment, this is referred to as a GRIN rod lens. However, use of other suitable GRIN lens systems is contemplated for use herein.

As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary.

With reference to FIG. **1**, the invention is embodied in a catheter, shown generally at **100**, including an imaging device and a transparent focal instrument **102** coupled to the catheter **100**, at a distal tip of the catheter **100**. The transparent fiscal instrument **102** has an outer periphery that is positioned at the effective focal plane of the imaging device. As shown, the outer periphery of the transparent focal instrument **102** can be placed in contact with bodily tissue **104** so that the bodily tissue can be in position to be "in focus" for imaging.

Because a target bodily tissue can be located in a relatively large bodily passage and because the catheter **100** is relatively small, as shown in FIG. **1**, it is often difficult to position the catheter **100** in proper position, such as in the free space of a large bodily passage, so that it can position the target area "in focus" with respect to the camera. However, due to the nature of catheter systems the distal end of a catheter is frequently in contact with bodily tissue as it is directed along curved bodily passages and cavities. When a semi-flexible catheter is directed along a bodily passage, for example, the lungs, veins, or gastrointestinal (GI) tract, the distal end of the catheter will typically be in contact with the outer edge of these passages when being directed around a turn. At these points of contact, the catheter having the transparent focal instrument can effectively image the outer walls of these passages in detailed and accurate focus.

The imaging device can include various camera and lens devices. In one exemplary embodiment the imaging device can include a SSID chip **132** and GRIN rod lens **130**, as shown in FIG. **8**. The SSID **132** can comprise a silicon or other semiconductor substrate or amorphous silicon thin film transistors (TFT) having features typically manufactured therein. In another embodiment, the SSID **132** can comprise a non-semiconductor substrate coated with a semiconductor material, or other equivalent structure. Features including the imaging array **134**, the conductive pads (not shown), metal traces (not shown), circuitry (not shown), etc., can be fabricated therein. With respect to the conductive pads, the connection between conductive pads and a conductive line of an umbilical or catheter body can be through soldering, wire bonding, solder bumping, eutectic bonding, electroplating, and conductive epoxy. However, a direct solder joint having no wire bonding between the electrical umbilical and the conductive pads can be preferred as providing good steerability can be achieved with less risk of breaking electrical bonding. In one embodiment, the conductive line of the umbilical can provide power, ground, clock signal, and output signal with respect to the SSID **132**. Other integrated circuit components can also be present for desired applications, such as light emitting diodes (LEDs), for providing light to areas around the GRIN rod lens **130**.

It is not required that all of these components be present, as long as there is a visual data gathering and sending image device present, and some means provided to connect the data gathering and sending device to a visual data signal processor. Other components, such as the umbilical, housing, adaptors, utility guides, and the like, can also be present, though they are not shown in FIG. **8**. The SSID **132** can be any solid state imaging device, such as a CCD, a CID, or a CMOS imaging device. Also, the GRIN rod lens **130** can be coated with an opaque coating on the curved surface to prevent light from entering the lens at other than the flat surface that is most distal with respect to the SSID **132**. Additional principles of operation and details of construction of similar micro-camera assemblies can be found in U.S. patent application Ser. Nos. 10/391,489, 10/391,490, 11/292,902, and 10/391,513 each of which are incorporated herein by reference in their entireties.

Reference will now be made to FIGS. **2***a*-**3***b*, which depict various embodiments of transparent focal instruments, in accordance with the principles of the invention. The catheter **100** includes an imaging device **106**. A transparent focal instrument **102** is coupled to the camera, for instance, the transparent focal instrument **102** can be coupled to the imaging device **106**, as shown in FIGS. **2***a*-**2***b*, or coupled to the catheter body as shown in FIGS. **2***c*-**3***b*. The transparent focal instrument **102** is configured to have an outer periphery that is positioned at a distance approximately equal to the distance from the imaging device **106** to the effective focal plane of the imaging device **106**. This distance is represented at **103**.

As different camera systems can have varying angles of view, the transparent focal instrument can have respectively varied shapes, contours, lengths, and other such properties. The exemplary embodiments of FIGS. **2***a*-**3***b* are intended to be presented herein as examples and are not intended to be all inclusive regarding the type, shape, or dimensions of potential transparent focal instruments.

The transparent focus instrument **102** can be a hollow spacer, solid spacer, inflatable or inflated balloon, or other such device as will be apparent to one of ordinary skill in the art. The spacer can be composed of glass or a transparent polymer which includes common transparent plastics such as polystyrene, polycarbonate, or PET.

Multiple imaging devices **106** can be included on a single catheter **100**, as shown in FIGS. **3***a*-**3***b*. Accordingly, the transparent focus instrument **102** can be configured to have an outer periphery at the effective focal plane of each imaging device **106**. When conducting certain endoscopic procedures it may be advantageous to include imaging devices that can image in lateral directions. Typically, catheter devices have a limit to the flexibility of the catheter body which limits the device's ability to turn and face a lateral object when in small or narrow passageways. As such, by including an imaging device that faces in one or more lateral directions as well as one or more transparent focal instruments, respectively, the catheter can be directed down a narrow passage of the body while imaging "in focus" the wall of the bodily passage.

In another embodiment the catheter **100** can include a turning device, as is known in the art. The turning device (not shown) can assist the catheter **100** to be directed to a target area of the body as well as turning the distal end of the catheter **100**, including the imaging device **106** and transparent focal instrument **102** towards a target object or area. This turning device can assist a user to accurately position the periphery of the transparent focal instrument **102** in contact with a desired tissue.

FIG. **4** depicts the catheter **100** according to one embodiment of the present invention, being directed through a bodily passage **104**. In this exemplary situation, the bodily passage **104** is substantially larger than the catheter **100** such that the transparent focal instrument **102** is not naturally in contact with the passage wall. An inflatable balloon **110**, coupled to the catheter **100**, which can be inflated to force the transparent focal instrument **102** in contact with the passage wail. Such a balloon can be designed and constructed by methods and materials currently known in the art.

FIGS. **6***a*-**6***b* illustrate a function of the inflatable balloon **116** represented in FIG. **4**. As shown, the catheter **100** can include a laterally-oriented imaging device **106** having a transparent focal instrument **102***g*. The inflatable balloon **116** is disposed on the side opposite the imaging device **106** and is attached to a fluid source **118** configured to inflate and deflate the balloon **116** with a fluid. As shown in FIG. **6***a*, the transparent focal instrument **102***g* is not initially in contact with the bodily passage wall **104**. FIG. **6***b* shows a fluid **120** being inserted into the balloon. The fluid **120** can include air, oxygen, saline solution, or other fluid known in the art. As the balloon **116** is filled with the fluid **120**, the transparent focal instrument **102***g* is positioned in contact with the passage wall **104**. As will be apparent, the balloon **116** can include a variety of shapes and sizes according to the needs of the user. In one embodiment, the balloon **116** can be non-spherically shaped when inflated, to allow the passage of fluids within the bodily passage, as shown in FIG. **4**. In another embodiment, the catheter **100** can include more than one inflatable balloon **116**, which can each selectively be inflated to position the transparent focal instrument **102***g* in contact with a target object/location. In another embodiment, the balloon **116** comprises a toroidal or torus structure to allow the passage of fluids through the otherwise occluded vessel.

Referring now to FIGS. **6***c* through **6***d*, a different method of laterally positioning the transparent focal instrument **102***g* is illustrated. In this embodiment the balloon shown in FIGS. **6***a* and **6***b* is replaced with a piece of preformed wire **117**, which when extended from the catheter **100** forms a coil which moves the transparent focal instrument **102***g* into contact with a target object/location. In one embodiment, the preformed wire **117** comprises a shape memory alloy such as Nitinol. In one aspect of the invention a plurality of imaging devices **106** may be disposed lengthwise along a side of the catheter body with corresponding focal instruments **102***g* and positioning devices. In this manner, a practitioner may capture numerous images of an interior of a patient as the catheter **100** is advanced within the patient.

FIG. **5** depicts the catheter **100** according to one embodiment of the present invention, wherein the transparent focal instrument is in the form of a transparent inflatable balloon **112**. When inflated the transparent inflatable balloon **112** has an outer periphery that is positioned at the effective focal plane of the imaging device, to enable objects in contact with the outer periphery of the transparent focal instrument to be imaged substantially in focus. The use of a flexible, transparent balloon **112** as a transparent focal instrument allows the catheter to maintain miniature dimensions due to the relatively low volume and flexibility of the balloon. Additionally, the transparent balloon **112** can act as an optical environment for the imaging device, displacing the fluids and other material that can obstruct the imaging path of the imaging device.

FIGS. **7***a*-**7***b* illustrate a function of the transparent balloon of FIG. **5** according to one embodiment of the present invention. In one aspect of the invention, catheter **100** comprises a lumen **124** extending from a distal end of the catheter **100** to a side portion of the catheter **100**. When deflated the transparent balloon **122** can be positioned along the catheter body, as shown in FIG. **7***a* effectively blocking the opening of lumen **124** on the lateral portion of the catheter body. As illustrated in FIG. **7***b*, when inflated, the transparent balloon **122** can form a transparent focal instrument wherein the distance **103** from the imaging device **106** to the outer periphery of the inflatable balloon **122** is equal to the distance **103** of the imaging device **106** to its focal plane. When in its inflated state, lumen **124** is open to the passage of fluids **126** through the vessel of the patient. Advantageously, while the distal end of the catheter **100** effectively occludes passage of any fluids **126** through the vessel of the patient, lumen **124** acts a temporary passageway for the fluids **126**. While a single balloon-imaging device combination is shown, it will be understood that a plurality of such combinations can be included with the present invention. In one exemplary embodiment of the invention the catheter **100** can include four such combinations positioned around the circumference of the catheter body. Each of these four transparent balloons can be selectively inflated, either synchronously or separately in order to image the walls of a bodily passage or bodily organ. Additionally, the transparent balloon-imaging device combination can be positioned in a forward facing orientation, as shown in FIG. **5**. The balloon can be inflated with air, oxygen, saline solution, or other fluid common to the art of balloon catheterization.

In another embodiment, the imaging device comprises a plurality of micro-cameras each having a different effective focal length and corresponding transparent focal instrument attached thereto. In one aspect, one of the plurality of imaging devices has a field of view that is larger than the other imaging devices. In yet another aspect, one of the plurality of imaging devices has magnification capabilities. In yet another aspect, the plurality of imaging devices may be oriented parallel to one another or may be configured in a non-parallel orientation as suits a particular application. Additional principles of operation and details of construction of GRIN lens microscope assemblies can be found in U.S. patent application Ser. No. 12/008,486 filed Jan. 1, 2008 and entitled "Grin Lens Microscope System" which is incorporated herein by reference in its entirety.

FIG. **9** is a flowchart of a method for imaging with a catheter. The method first includes providing a catheter with a transparent focal instrument having an outer periphery that is positioned at the effective focal plane of an imaging device **210**. The transparent focal instrument can be of a variety of configurations as described in detail above. Next, the method includes positioning the outer periphery of the transparent focal instrument in contact with a target object, to enable a target object in contact with the outer periphery of the transparent focal instrument to be imaged substantially in focus **220**. Various methods and devices can be used to position the transparent focal instrument in contact with a target object. In addition to the methods and devices described above, the catheter body can be rotated around its longitudinal axis and/or the imaging device can include turning devices, such as piezoelectric actuators, for tilting and/or moving the imaging device. Additionally, the focal length of the camera can be modified in certain cameras, while the distance between the imaging device and the outer periphery of the transparent focal instrument is respectively modified. Lastly, the target object is imaged by the imaging device **230**. In one embodiment of the present invention, the imaging device can be constantly imaging, so as to record and display live images to a user. Alternatively, the imaging device can include an additional feature, wherein enhanced images are selectively taken, that can be analyzed and viewed to assist in diagnosis and analysis.

Advantageously, embodiments of the present invention include a transparent focal instrument for a catheter to assist a medical practitioner to image objects that are in contact with the transparent focal instrument substantially "in focus," Thus, improved catheter imaging can be achieved by maneuvering the transparent focal instrument in contact with a target tissue/object. Such a maneuver can reduce the trial-and-error procedure of maneuvering the distal end of a catheter within a bodily passage/cavity. This can allow a user to image more tissue in less time and with higher resolution because the transparent focal instrument can be passed over a potentially diseased area or quickly and repeatedly positioned against a passage wall as it is directed down the passage. Additionally, this device can substantially enhance a catheter's ability to image critical tissue, such as potentially cancerous cells/regions in higher definition and with increased clarity, thus increasing a user's ability to diagnose and treat problems. As such this device can dramatically improve a doctor's ability to detect various illnesses and diseases at their early stages.

While the forgoing examples are illustrative of the principles of the present invention in one or more particular applications, it will be apparent to those of ordinary skill in the art that numerous modifications in form, usage and details of implementation can be made without the exercise of inventive faculty, and without departing from the principles and concepts of the invention. Accordingly, it is not intended that the invention be limited, except as by the claims set forth below.

What is claimed is:

1. A catheter configured for imaging objects substantially in focus, comprising:

a) an imaging device disposed on a distal end of the catheter, the imaging device having an effective focal plane;

b) a transparent focal instrument coupled to the catheter, the transparent focal instrument having an outer periphery, wherein a length from the imaging device to the outer periphery of the transparent focal instrument is equal to the distance from the imaging device to the effective focal plane of the imaging device; wherein when the outer periphery is positioned at the effective focal plane of the imaging device, it enables objects in contact with the outer periphery of the transparent focal instrument to be imaged substantially in focus; and

c) an open channel having a first orifice disposed about a side surface of the catheter in fluid communication with a second orifice on a distal end of the catheter, wherein the imaging device is located inside an inflatable balloon and wherein the inflatable balloon is configured to cover the first orifice of the catheter when deflated for limiting fluid communication in the open channel.

2. The catheter of claim **1**, wherein the imaging device comprises a solid state imaging device including an imaging array and a graduated refractive index lens optically coupled to the imaging array of the solid state imaging device.

3. The catheter of claim **2**, wherein the transparent focal instrument is coupled to the graduated refractive index lens.

4. The catheter of claim **1**, wherein the imaging device includes at least two imaging devices.

5. The catheter of claim **1**, wherein the imaging device is configured to image in a lateral direction with respect to a longitudinal axis of the catheter.

6. A catheter configured for imaging objects substantially in focus, comprising: a) an imaging device disposed on a distal end of the catheter, the imaging device having an effective focal plane; b) a transparent focal instrument coupled to the catheter, the transparent focal instrument having first and second positions, wherein when disposed in the second position, the transparent focal instrument has a length that is equal to the distance between the imaging device and the effective focal plane of the imaging device and is positioned at the effective focal plane of the imaging device to enable a target object in contact with an outer periphery of the transparent focal instrument to be imaged substantially in focus, wherein the transparent focal instrument comprises an inflatable balloon; and c) a channel having a first orifice disposed about a side surface of the catheter adjacent a distal end of the catheter, and a second orifice disposed about a distal end of the catheter, the first orifice being in fluid communication with the second orifice, wherein when the inflatable balloon is disposed in the second position, the channel extends from a first side of the inflatable balloon to a second side of the inflatable balloon to permit fluids within a vessel of a patient to pass from one side of the inflatable balloon to the second side of the inflatable balloon, wherein when the inflatable balloon is disposed in the first position, the inflatable balloon is configured to cover the first orifice of the catheter for limiting fluid communication in the channel.

7. A method for imaging with a catheter, comprising:

a) providing a catheter having a channel disposed therein and a transparent focal instrument, the transparent focal instrument comprising first and second positions wherein when the transparent focal instrument is disposed in the first position, the transparent focal instrument covers an opening of the channel and wherein when the transparent focal instrument is disposed in the second position, the transparent focal instrument does not cover the opening of the channel and has an outer periphery with a length equal to the length of the effective focal plane, the transparent focal instrument being positioned at an effective focal plane of an imaging device;

b) inserting the catheter into a cavity of a patient while the transparent focal instrument is disposed in the first position;

c) after inserting the catheter into the cavity of the patient, disposing the transparent focal instrument in the second position thereby occluding the cavity of the patient with the transparent focal instrument and removing the transparent focal instrument from the opening of the channel; and

d) imaging a target object.

8. The method of claim **7**, wherein the transparent focal instrument comprises a balloon.

9. The method of claim **8**, wherein positioning the outer periphery of the transparent focal instrument includes inflating the balloon disposed on the catheter to move a distal end of the balloon in contact with the target object.

10. The method of claim **7**, wherein the transparent focal instrument comprises a transparent balloon having an inflated length substantially equivalent to the effective focal plane of the imaging device.

11. The method of claim **7**, wherein the imaging device is configured to image objects lateral to a longitudinal axis of the catheter.

12. The method of claim **7**, wherein positioning the outer periphery of the transparent focal instrument includes inflating a balloon disposed on the catheter to move a distal end of the balloon in contact with the target object.

13. The method of claim **12**, wherein the transparent focal instrument is substantially solid.

14. The method of claim **12**, further comprising a plurality of imaging devices disposed about an exterior of the catheter and a plurality of balloons, each balloon enclosing a single imaging device.

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